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(71) Applicant: AG-CHEM EQUIPMENT CO., INC. [US/US]; Suite 100, 5720 Smetana Drive, Minnetonka, MN 55343-9688 (US).

(72) Inventors: MICHAEL, T., Vickers; 14660 13th Avenue North, Plymouth, MN 55447 (US). JIANHUA, Yan; Apartment 606, 4810 Highway 7, St. Louis Park, MN 55416 (US). ROBERT, J., Monson; 1027 Brenner Avenue, St. Paul, MN 55113 (US).

(74) Agent: KVALE, Deirdre, Megley; Larkin, Hoffman, Daly & Lindgren, Ltd., 1500 Norwest Financial Center, 7900 Xerxes Avenue South, Bloomington, MN 55431 (US).

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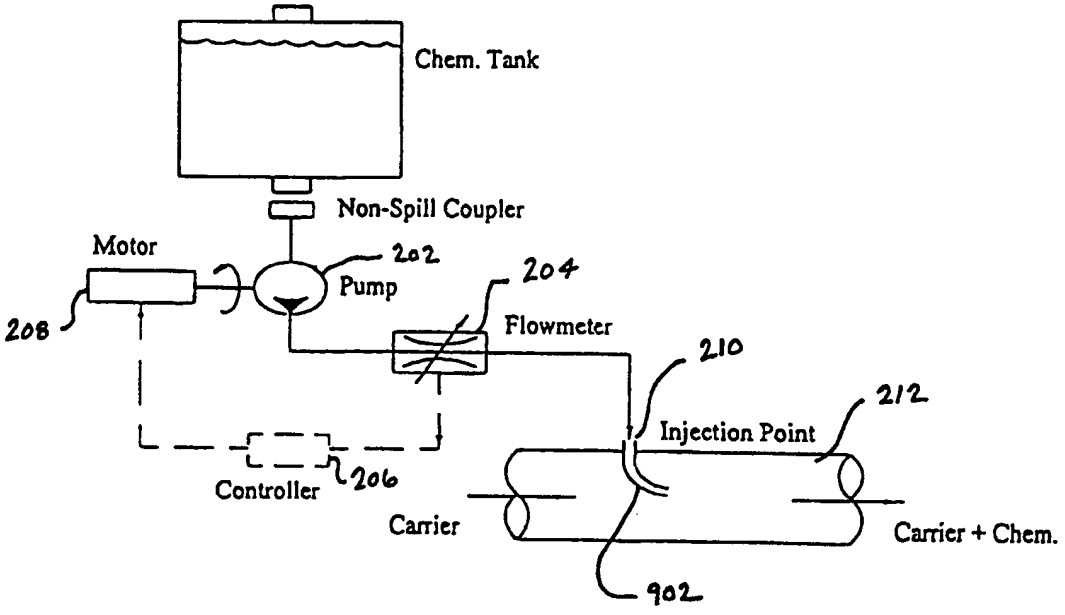

(57) Abstract

A comprehensive, closed transfer product delivery system, TALON™ (Total Application Logistics Operating Network) allow product applicators to safely deliver product, e.g. chemical(s) from a bulk tank (502) to the field without tank mixing the concentrated product with the carrier product, e.g. water, liquid fertilizer, etc. The product delivery system utilizes an advanced direct product injection sub-system using an injection pump (202) that is linked to an on-board computer (206) via an in-line product flow meter (204) for rate change feedback. The rate control can be a constant rate based on vehicle speed or variable rate application based on vehicle speed, and a digital map of soil data, crop data and/or survey, for example.

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COMPREHENSIVE PRODUCT DELIVERY SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a comprehensive product, e.g. chemical delivery system, and more particularly to a product delivery system which will allow product applicators to safely deliver concentrated products, e.g. chemical(s) from a bulk tank(s) to a field without tank mixing the concentrated product(s) with a carrier product.

2. Description of the Prior Art

The present state of the art regarding design of liquid application systems can be categorized as either 1) open tank mixing of concentrated products and carrier product(s) in the main product tank, or 2) direct injection of concentrated product(s) at some point in the carrier or boom plumbing. These existing concepts generally utilize some form of control system to apply a product/carrier mixture at a pre-selected, constant application rate based on the ground speed of the vehicle used in the application. A common problem that arises in these known systems is the lack of any accurate or reliable feedback from the chemical pump to the control system to allow for making adjustments to accommodate changing vehicle speeds. There is also no provision for variable rate application, or variable blend (fragmented application based on map input(s)).

Open tank mixing of the concentrated product/carrier mixture presents certain problems to the applicator in that the main product tank is continuously exposed to various brands and concentrations of products which introduces the possibility of residual product(s) remaining behind when using a new product, e.g. chemical. Additionally, once the concentrated product is diluted in the carrier mixture, it becomes unsaleable at a later date should the applicator not be able to deliver the mixture due to weather, equipment problems, etc. The complete product tank at this point (usually 500 gallons or more)

becomes hazardous waste. The product filling process during an open tank mixing operation also involves open product containers which pose potential safety and liability issues.

Direct injection utilizing permanent 'on-board' concentrated product tanks also poses potential contamination problems. Although there is no dilution of the concentrated product until it is introduced into the boom plumbing, the permanent product tanks are still used to contain multiple product brands which introduces the possibility of leaching or residual chemical(s). The need for rinsing creates problems, especially when the machine is still in the field, to safely dispose of the rinsate. This is a very undesirable characteristic because product tanks that are not thoroughly cleaned will contain residue which can accidentally be mixed with a non-compatible product causing crop damage and/or environmental hazards.

It is therefore desirable to provide a product delivery system which overcomes the shortcomings of present product delivery systems, as described hereinbefore. The present invention is one such system, and which entails a comprehensive, closed transfer product delivery system (Total Application Logistics Operating Network) which allows product applicators to safely deliver product(s) from the bulk tank to the field without tank mixing the concentrated product with the carrier product (water, liquid fertilizer, etc.).

U.S. Patent No. 5,340,210, issued to Patel et al. on August 23, 1994, *Apparatus For Blending Chemicals With A Reversible Multi-Speed Pump*, discloses an apparatus for blending chemicals in a blending vat, similar to the open tank product mixing system described hereinbefore, and having many of the attendant disadvantages normally associated with such known mixing systems.

U.S. Patent No. 5,310,113, issued to Cowgur on May 10, 1994, *Sprayer Control System And Method For Using Same*, discloses a sprayer control system and method for using a pump for directing a mixture of chemical and fluid carrier to a flow control valve, utilizing a f low control valve and associated flow control sensor, similar to the direct

injection systems described hereinbefore, and having many of the attendant disadvantages normally associated with such known systems.

U.S. Patent No. 5,278,423, issued to Wangler et al. on January 11, 1994, *Object Sensor And Method For Use In Controlling An Agricultural Sprayer*, discloses a sensor and method for determining the presence and size of foliage, such as trees or row crops, for purposes of spraying, counting or measuring the size of the foliage, but does not disclose apparatus or methods for overcoming many of the attendant disadvantages normally associated with either open tank mixing or direct product injection systems recited hereinbefore.

U.S. Patent No. 5,033,397, issued to Colburn, Jr. on July 23, 1991, *Soil Chemical Sensor And Precision Agricultural Chemical Delivery System And Method*, discloses a real time soil chemical sensor and precision agricultural chemical delivery system including a plurality of ground-engaging tools in association with individual soil sensors which measure soil chemical levels, but does not disclose apparatus or methods for overcoming many of the attendant disadvantages normally associated with either open tank product mixing or direct injection systems recited hereinbefore.

U.S. Patent No. 4,714,196, issued to McEachern et al. on December 22, 1987, *Farm Chemical Delivery System*, discloses a fluid delivery system for delivering at least one chemical onto a field in a desired concentration, but does not disclose apparatus or methods for overcoming many of the attendant disadvantages normally associated with either open tank product mixing or direct product injection systems recited hereinbefore.

U.S. Patent No. Re 31,023, issued to Hall, III on September 7, 1982, *Highly Automated Agricultural Production System*, discloses a fluid delivery subsystem of the open tank chemical mixing variety disclosed hereinbefore, and has many of the attendant disadvantages recited above normally associated with those known systems.

SUMMARY OF THE INVENTION

The present invention, directed to a comprehensive, closed transfer product delivery system (hereinafter known as "Total Application Logistics Operating Network" or "TALON™"), is composed primarily of three basic parts, including:

1) a distributed network control system, e.g. FALCON™, manufactured by Ag-Chem Equipment Co., Inc., and described in U.S. Patent Application S/N 08/243,506, entitled *Mobile Control System Responsive To Land Area Maps*, by Robert J. Monson, filed May 16, 1994, now incorporated herein by reference in its entirety;

2) an advanced response delivery system; and

3) a closed transfer product shuttle tank network.

The inventive product delivery system utilizes a distributed network control system to greatly simplify and enhance the overall system performance. This feature allows the system to be expanded in such a way that any system employing fewer control loops will not incur any incidental costs or complexities associated with a system employing many more control loops.

The present invention also employs an advanced response delivery system which includes:

1) a high precision diaphragm pump to maximize accuracy of product delivery over a wide range of chemical viscosity, offering improvements over conventional piston plunger or peristaltic pumps;

2) in-line product metering, offering improved real-time dynamic product flow control; and

3) a pre-charged liquid spray boom, effectively eliminating system lag time when the boom is activated.

Finally, the present invention also employs a closed transfer product shuttle tank network to carry the product(s) through a field on-board the product application vehicle, offering revolutionary applicator flexibility.

As the custom application industry is called upon to become the primary administrator of agricultural products, it becomes increasingly important that the custom applicator be afforded a safe, simple and reliable system to administer these products to the field. The TALON™ Delivery System now brings product application technology to a previously unrealized level of safety and precision within the industry.

Still another feature of the present invention includes a liquid injection nozzle which offers improved injection quality for product injection applications, especially for those applications having extremely low injection flow rates.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features of the present invention and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIG. 1 is a block diagram illustrating one preferred embodiment for a distributed network control system such as FALCON™, suitable for use with the present inventive comprehensive product delivery system;

FIG. 2 is a block diagram depicting one preferred embodiment for an advanced response delivery system suitable for use with the present inventive comprehensive product delivery system;

FIG. 3a is a schematic diagram illustrating one embodiment for a conventional liquid spray boom ;

FIG. 3b is a schematic diagram illustrating one preferred embodiment for a pre-charged liquid spray boom, suitable for use with the present inventive product delivery system;

FIG. 4a is a front view of one preferred embodiment of a closed transfer product shuttle tank, suitable for use with the present inventive product delivery system;

FIG. 4b is a side view of the closed transfer product shuttle tank illustrated in Figure 4a;

FIG. 5 is an illustration depicting operation of the closed transfer product shuttle tank shown in Figures 4a and 4b, where product or transferred media are completely closed to the atmosphere;

FIG. 6 is a perspective view of the closed transfer product shuttle tank shown in Figures 4a and 4b, showing one preferred tank shape;

FIG 7. is a perspective view illustrating the stacking feature of the closed transfer product shuttle tank, depicted in Figures 4a and 4b;

FIG. 8 is a perspective view of the closed transfer product shuttle tank mounted to a tank receiver on board a vehicle sprayer; and

FIG. 9 is a diagram illustrating one preferred embodiment for an injection nozzle, suitable for use with the present inventive product delivery system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention described as follows, addresses the considerable problems associated with present product delivery systems, including those product delivery systems utilizing open tank mixing of concentrated products and carrier products, as well as direct injection of concentrated products.

Looking now at Figure 1, a block diagram illustrates one embodiment for a distributed network control system 100 suitable for use with the present inventive comprehensive product delivery system. One such control system has been disclosed in U.S. Patent Application S/N 08/243,506 referenced hereinbefore. The use of a distributed network control system 100 will greatly simplify the concept and enhance the overall system performance for the present invention by creating a system that is easily expandable and upgradeable. Thus, a system operator may choose as few as one loop or

as many as desired in the case of multiple or fragmented product delivery requirements. The single loop unit will not in any way be incurring incidental costs or complexities associated with the multi-loop unit.

Use of a distributed network control system 100 enhances the comprehensive, closed transfer product delivery system by providing the system with the ability to control pre-plant, pre-emerge, and post emerge products in accordance with an on-board digital field map based on soil samples or pest surveys. Generally, the vehicle position will be input to an on-board computer either via a Global Positioning Satellite signal such as AgNav™ or by simple dead-reckoning.

Moving now to Figure 2, there is illustrated one preferred embodiment of an advanced response delivery system 200 suitable for use with the present invention. The advanced response delivery system 200 is preferably composed of three basic elements, which, along with the remaining portions of the present inventive product delivery system, provide many revolutionary concepts, which will now be detailed hereinafter.

Delivery system 200 preferably utilizes a high precision diaphragm pump 202 having three separate and distinct diaphragms to reduce pulsation and increase resolution. Delivery system 200 is preferably a self-priming system which is directly driven by a 12 volt DC motor 208 which in turn is preferably controlled by a pulse width modulated (PWM) motor controller 206. Diaphragm pump 202 provides optimal efficiency in pumping chemical(s) through a working pressure section which is completely isolated from the remaining pump's 202 mechanical components via three robust diaphragms, not illustrated for clarity and simplicity. Preferably, pump 202 diaphragms are manufactured from a tough, chemical-resistant material for long service life. It is also preferable that diaphragm pump 202 be completely serviceable by the system operator. It will be appreciated by those skilled in the art that a diaphragm pump 202 is much more accurate in delivery over a wide range of product viscosity than conventional piston plunger or peristaltic pumps.

Advanced response delivery system 200 also preferably includes in-line product metering, e.g. flowmeter 204 for real-time dynamic product flow control. It will be appreciated by those skilled in the art that such real-time dynamic product flow control is the first of its kind to be employed in a product delivery system. This feature plays a major role in the present inventive system's ability to accurately deliver feedback to a control loop within distributed network control system 100. It will be appreciated that each product loop has it's own metering device 204. This feedback mode is greatly enhance by the PWM motor controller's 206 ability to react quickly and accurately. Preferably, the system 200 operator is also notified immediately in the case of loss of product flow.

Looking again at Figure 2, product injection point 210 is depicted protruding into the carrier line 212 . Preferably, injection point 210 protrudes into carrier line 212 such that any product(s) is injected downstream as shown.

Figure 3a illustrates a liquid spray boom shut-off system 300 generally known to those skilled in the art. Typically, in a conventional boom system 300, individual boom sections are manifolded into sections with an in-line valve 302. It is known to those skilled in the art that any air trapped in the spray boom 304 downstream of valve 302, will expand and compress while using a conventional boom shut-off system 300. It is virtually impossible to eliminate all air trapped in a liquid system boom 304. This expansion and compression results in undesirable effects and inefficient lag time when the boom 304 is turned on. Such undesirable effects are eliminated with the present invention by providing a pre-charged liquid spray boom shut-off system 310 such as illustrated in Figure 3b. In Figure 3b, each boom section 304 includes an individual shut-off nozzle 312 within the respective boom section 304 that is manifolded into the desired number of sections. In this manner, each boom line 306 remains charged with current pump pressure and entrapped air remains at a constant pressure, thereby eliminating the expansion and compression, and also effectively eliminating system lag when the respective boom 304 is turned on.

Operators of mobile crop spraying equipment require a system to safely transfer and apply agricultural products in the field. A durable linear polyethylene family of product tanks is needed to fill the gap between what product, e.g. chemical companies use as packaging and what the equipment operators need as a medium to transport the product(s) through the field on-board a crop sprayer. Any shuttle tank system must have the capability to adapt to any form of product packaging for effective closed transfer of the product which dramatically reduces the risk of incidental product contact by the system operator. Preferably, the tanks will also be designed to have the ability to be dedicated on one specific product for a given period of time (determined by the operator) so the tank will only be rinsed periodically under controlled conditions.

Figure 4a illustrates one preferred embodiment for a closed transfer product shuttle tank 400 for use with the present invention. The present inventive product delivery system utilizes a unique design polyethylene product shuttle tank 400 to carry the product(s) through a field on-board a product application vehicle (not illustrated). It will be appreciated that multiple tanks and tank sizes can be used. Each tank 400 preferably has the same cross section and different sizes will vary in height only. In this manner, all such tanks 400 will then be able to be mounted on the same tank cradle on the vehicle. Preferably, shuttle tanks 400 will be color-coded to allow the product applicator to match tank quantities and sizes with specific product labels via color codes based on demand of a particular product type at any point in the application season. This color-coded feature allows the applicator flexibility in designing their own shuttle tank 400 network and revising this design at any point. Typically, tanks 400 would then be thoroughly rinsed under controlled conditions at the end of the season, if necessary. Figure 4b illustrates another view of shuttle tank 400 depicting additional tank 400 features.

As the custom application industry is called upon to become the primary administrator of agricultural products, it becomes increasingly important that the custom applicator be afforded a safe, simple and reliable system to deliver these products to the field. By providing these product applicators a completely closed-transfer product fill,

along with dramatic injection and control system advances, the present inventive system brings product application technology to a previously unrealized level of safety and precision within the industry.

Mobile crop spraying equipment manufacturers are in a position where they must now depend on the product companies to package the product (agricultural chemicals, pesticides, etc.) in such a manner that the end user, e.g. equipment operator has a safe, easy way to transfer the product from the factory packaging to the mobile equipment for end use. It will be appreciated by those skilled in the art that this is rarely the case. Due to the extreme variety of products and pesticides, for example, available on the market and the wide variety of equipment manufactured to apply these products, a wide gap exists in the ability of equipment manufacturers or product companies to allow for the safe transfer and application of agricultural products. The present invention preferably utilizes a dedicated, reusable shuttle tank network to fill the gap between the important packaging and marketing strategies of the product companies and the ability of the equipment operator to safely deliver the product to the field. The equipment operators and manufacturers will no longer depend on the product companies to conform to any certain packaging criteria, yet retain the ability to run a completely closed-transfer operation from the bulk tank to the field.

Moving now to Figure 5, one preferred embodiment 500 illustrating use of the inventive shuttle tank 400 in a closed transfer operation is shown where product or transferred media are completely closed to the atmosphere. This shuttle tank 400 concept is based upon the idea that access is gained to the shuttle tank 400 (receiving medium) and the bulk or packaged product tank 502 (filling medium) through a series of "dry lock" couplings 504 that are closed to the atmosphere and are 'no drip' or 'no spill' by design. One preferred embodiment for the shuttle tank system design concept includes the shuttle tank 400 (receiving medium) itself, any and all adapter fittings 504 required to gain access to the filling or receiving medium, custom plumbing 506 required, and the "quick mount" system, illustrated in Figure 8, used to install the receiving medium on to a crop

sprayer. This concept also includes reversing this process to return unused (undiluted), product back into the bulk tank (system) 502.

As stated hereinbefore, an important aspect of this inventive concept is that the shuttle tank 400 be dedicated to only one product for a given period of time (determined by the operator). The operator may choose to have multiple tanks 400 available for one or more products. It will readily be appreciated by those skilled in the art that since the tank 400 is dedicated to one product, the only time the tank 400 need be cleaned or rinsed, is when the operator chooses to switch products for which this tank 400 is dedicated. This is advantageous over known systems since the rinsing can be done at the operator's discrepancy under controlled conditions. This feature eliminates the need for in-field tank rinsing and eliminates hazardous rinsate on a daily basis which enables the operator to become more efficient in both operating safely and lowering operating expenses. Diluted product rinsate (concentrated product mixed or diluted with water or fertilizer, for example), that is left over after spraying is an environmental hazard that is costly in many ways. It is apparent that if an operator never has to dilute the product (until it is delivered to the spray boom 304 on-board the crop sprayer), then the instance of left over rinsate is eliminated. Any left over product in the shuttle tank 400 is undiluted and can be reused or transferred back into the bulk system 502 for use at a later date.

Figure 6 illustrates a perspective view of one preferred embodiment 600 of shuttle tank 400 showing a preferred modular concept. Preferably, the cross-sectional area of tank 400 is such that the tank 400 capacity (in gallons) equals the effective height of the tank 400 (in inches). The only difference between various tank 400 sizes then, is the height of the tank 400. Preferably, tank 400 includes a separate removable tank 400 stand 602 designed such that these tanks 400 become "stackable" for storage. It can be seen that the bottom stand 602 mates to the upper portion of the tank 400, regardless of tank 400 size. It is preferable that tank 400 be provided with "no drip" or "no spill" couplings 504 for gaining access to the tank 400 for easy filling and delivery of product.

Figure 7 illustrates yet another perspective view 700 depicting the manner in which tanks 400 are stacked for storage. Tank 400 includes a "double tapered" sump area 702 for complete draining of product. Tank stand 602 is designed to accommodate sump area 702 and to protect bottom dry break connection 802 shown in Figure 8 and insure that the tank 400 rests evenly on the ground or on the machine. Preferably, tank 400 includes grab handles 704 on the upper portion of the tank 400, formed such that a fork lift can easily slide through the handles 704 for tank 400 handling. Tank 400 can optionally be provided with a threaded indentation for adding a tank level sensor 706 in a manner familiar to those skilled in the art. It will readily be appreciated to those skilled in the art that vents 504 and 802 should preferably be provided with check valves 708 to prevent liquid spillage in the event of a tip-over. Looking again at Figure 7, tank 400 can be seen to include a removable color card or label holder 710 for added tank 400 flexibility of use. It is preferable that tank 400 include a built-in mechanical agitation device 712 that will permanently remain with the tank 400. The importance of such an agitator device 712 readily becomes apparent when one skilled in the art realizes that the agitator device 712 often becomes immersed in the product. Preferably, device 712 is powered by a 12 volt DC motor that is easily detachable from the tank 400 for remaining with the vehicle.

Figure 8 illustrates one preferred embodiment for a shuttle tank 400 such as that shown in Figure 4, mounted on-board a vehicle sprayer 800. Tank 400 fits securely into tank receiver 802 which is adapted to fit all tank 400 sizes. Hold down means, such as a hold down strap 804, is preferably used to secure the tank 400 to the tank receiver 802. Looking again at Figure 8, the pump inlet 806 and dry break connection 808 for attaching pump inlet plumbing 810 can be seen. It will be appreciated by those skilled in art that many other adaptations, modification and alterations may just as easily be used for these inlets 806 and connections 808.

The present invention preferably includes a closed product transfer system as described hereinbefore, which includes a dedicated and reusable product shuttle tank(s) 400 and a modular "systems" design approach to incorporating important tank 400

features, also described hereinbefore. Those skilled in the art will readily appreciate the important gap filled between the product companies' diverse packaging strategies and the ability of the product applicator to safely deliver products to the field. A dedicated, reusable product shuttle tank 400 system on a mobile crop sprayer 800, for example, will have a significant, positive impact on the ability of the product applicator (operator) to deliver products and pesticides, for example, to the field safely and efficiently. The closed product transfer system described hereinbefore makes it easy to be safe and environmentally friendly.

Looking again at Figure 2, one preferred embodiment for a high precision closed loop control system 200 with in-line metered 204 flow feedback, suitable for use with the present inventive comprehensive product delivery system, is illustrated. As stated hereinbefore, an in-line flow metering concept will offer real-time dynamic product flow control capability to a closed loop control system. Together with a precision triple diaphragm pump 202, a PWM motor controller 206, and an in-line injection nozzle 902 illustrated in Figure 9, the in-line flow metering provides the control system 200 with more accurate, reliable and faster response for product injection applications, also as stated hereinbefore.

It will be appreciated by those skilled in the art that metering accuracy for product injection applications becomes an increasingly important issue due to low injection flow rates and the cost of highly concentrated products, e.g. chemicals. For a closed loop product injection control system, a motor speed has generally been used as a reference measurement for product flow rates and as a feedback signal to a controller. The number of revolutions per minute (rpm) of a motor was typically calibrated with respect to the product discharge rates from a pump which led to numerous problems, including, but not necessarily limited to: 1) At a constant motor rpm, the metering pump, usually a positive displacement pump, discharges a fixed product flow rate. However, when the pump and/or the plumbing has any leakage, clog, or priming problems, the controller will receive a fault feedback signal by reading the constant rpm, which will cause under

application of chemicals; 2) Different products have different viscosities. Even for a known product, its viscosity will change with temperature. The variation in viscosity may affect the pump's output by a +/-10%-18% of full scale for a given motor rpm. This inaccuracy range is not acceptable for injecting highly concentrated products for spraying applications; and 3) To reduce an inaccuracy range down to +/-5%, Re-calibration of the injection system is required when changing different viscous chemicals, or when the product tank is run empty and refilled for the next operation (due to the pump priming problems). The present invention overcomes these problems by monitoring the actual flow rate, and controlling the motor 208 rpm accordingly.

Figure 2, described in more detail hereinafter, illustrates one preferred embodiment for the inventive closed loop control system 200 suitable for use in product injection applications such as the present inventive comprehensive product delivery system. The in-line flowmeter 204 offers real-time dynamic product flow control. Together with a precision triple diaphragm pump 202, a PWM motor controller 206, and an in-line injection nozzle 902, the in-line metered flow feedback provides the control system 200 with more accurate, reliable and faster response for product injection applications, as stated hereinbefore.

The controller 206 compares a target flow rate (corresponding to the vehicle ground speed) with the actual product flow rate (feedback signal). Based on the measured error, the controller 206 will alter the motor 208 speed via, for example, a PWM motor driver to ensure actual flow rate matching the target flow set point.

As stated hereinbefore, the great advantage of using a triple diaphragm pump is that for a given flow rate, a triple diaphragm pump has much less pulsation flow than a single and/or dual piston pump, so that the injection system can evenly distribute products to the spraying nozzles on a timely basis. The diaphragms inside the pump 202 separate the products from the moving parts of the pump 202, so that the pump 202 can be run dry in case of running out of products in the tank 400. The in-line flowmeter 204 makes the product delivery system able to accurately monitor the actual product flow rate

within a wide range of viscosity, and notifies the operator immediately in the case of loss of product flow. The response time and accuracy of the closed loop control system 200 are greatly enhanced by the PWM motor driver, and the product injection point 210 protruding into the carrier 212 streamline as shown in Figure 2.

Figure 9 illustrates in more detail, the product injection point 210, including one preferred embodiment for a liquid injection nozzle 902 in accordance with the present invention. Injection nozzle 902 was adapted to ensure complete delivery of liquid injected into the carrier line (conduit) 212 by improving injection quality for product injection applications, especially for those applications having extremely low injection flow rates.

The embodiment depicted in Figure 9 preferably has a tee fitting assembly 904 located downstream of the product, e.g. chemical injection pump 202 and is pressurized to approximately 40-70 psi, depending on the flow rates, at the product injection point. The present invention is not so limited however, and it will be appreciated that other pressures will also be effective in a particular application having characteristics unique to that application. It has been found by the present inventors that high pressures inside the tee fitting assembly 904 may cause problems, including, but not necessarily limited to: 1) These high pressures require higher pressure on the product injection pump 202 to inject products into the carrier line 212, which may lead to a higher liquid slippage inside the product pump 202; and 2) There will be some vortex disturbances at the tee's 904 upright area, consequently causing an uneven delivery and/or a longer time delay of the product into the carrier line 212. Injection nozzle 902, described in more detail hereinafter, improves product injection quality by removing the problems identified hereinbefore.

Most preferably, a 90^0 bent tube 902 is protruded into a conduit 212. Additive liquid (chemicals) will be injected through the outlet 908 of the tube 902 into the carrier 212 liquid. The outlet 908 of the injection tube 902 is preferably located in the centerline of the conduit 212 and the injected liquid stream is parallel to the carrier 212 liquid stream lines. Since the outlet 908 of injection tube 902 is surrounded completely by the

carrier liquid, all the injected liquid out of the tube is carried away without trapping any amount of the injected liquid anywhere inside the conduit 212. In this manner, it is ensured that all the additive liquid injected into the carrier line 212 will be carried out toward the in-line mixer (not illustrated). The effect of vortex disturbances on injected flow will thus be eliminated and the injection and mixing quality improved, especially for low product applications rates. It is important to note that injection tube 902 and conduit 212 have a fixed inside diameter respectively so that the restriction or pressure drop in the injection and carrier plumbing is minimized. In one preferred embodiment, conduit 212 has male threads on both ends, and the injection inlet 906 has female threads for easy connection in existing liquid plumbing systems.

This invention has been described herein in considerable detail in order to comply with the Patent Statutes and to provide those skilled in the art with the information needed to apply the novel principles and to construct and use such specialized components as are required. However, while a particular embodiment of the present invention has been described herein in detail, it is to be understood that various alternations, modifications and substitutions can be made therein without departing from the spirit and scope of the present invention, as defined in the claims which follow. For example, it will be appreciated that the comprehensive product delivery system has principles that may be applied to product delivery systems in general, and thus is not necessarily restricted to application of products in the agronomic industry.

WE CLAIM:

1. A product delivery system, comprising:

a self-propelled vehicle; and

a closed transfer product storage means removably coupled to said vehicle, for storing and transporting at least one predetermined product from at least one bulk source to a predetermined geographical location.

2. The product delivery system according to Claim 1, wherein said closed transfer product storage means comprises at least one modular shuttle tank, said at least one tank having a sump area for allowing complete draining of said at least one product from said at least one tank.

3. The product delivery system according to Claim 2, wherein said closed transfer product storage means further comprises a stand removably coupled to said at least one tank, said stand adapted to allow a plurality of said tanks to be stacked upon one another.

4. The product delivery system according to Claim 2, wherein said at least one tank further comprises grab handles having voids adapted to allow insertion of at least one fork lift truck fork, such that said at least one tank can be transported by said fork lift truck.

5. The product delivery system according to Claim 2, wherein said at least one tank further comprises a threaded indentation adapted for mounting a product level sensor.

6. The product delivery system according to Claim 2, wherein said at least one tank further comprises at least one closed coupling adapted to gain access to said at least one tank to accommodate filling and delivery of said product.

7. The product delivery system according to Claim 2, wherein said at least one tank further comprises a mechanical agitation means coupled to an interior surface of said at least one tank, for mixing said product.

8. The product delivery system according to Claim 2, wherein said at least one tank further comprises a product label removably coupled to an exterior surface of said at least one tank, said product label for identifying said at least one stored product.

9. The product delivery system according to Claim 8, wherein said product label comprises a color card based on a remote legend for identifying said at least one stored product.

10. The product delivery system according to Claim 8, wherein said product label is laminated.

11. The product delivery system according to Claim 2, wherein said at least one tank further comprises a label holder removably coupled to an exterior surface of said at least one tank.

12. The product delivery system according to Claim 1, further comprising a distributed network control system coupled to said vehicle, said control system controlling a rate of delivery of said at least one product from said at least one tank to said geographical area, said control system being responsive at least one field map based on at least one agriculture-related sensable attribute.

13. The product delivery system according to Claim 1, further comprising a pumping means for pumping said at least one product from said at least one tank to said field.

14. The product delivery system according to Claim 13 wherein said pumping means comprises a dc motor, said motor comprising a pulse width modulated motor driver.

15. The product delivery system according to Claim 13, wherein said pumping means comprises a triple diaphragm pump.

16. The product delivery system according to Claim 14, further comprising an in-line flowmeter, said flowmeter for accurately monitoring actual flow rates for said at least one product, said flowmeter further for providing signals to an operator indicative of loss of product flow.

17. The product delivery system according to Claim 16, further comprising a controller coupled to said flowmeter, said controller for receiving said flowmeter signals and controlling said motor driver via said flowmeter signals.

18. The product delivery system according to Claim 1, further comprising a product injection means for ensuring complete delivery of said product into a carrier line.

19. The product delivery system according to Claim 18, wherein said product injection means comprises a tubular nozzle having an inlet and an outlet, said nozzle having a fixed inside diameter.

20. The product delivery system according to Claim 19, wherein said tubular nozzle comprises a 90^0 bent tube such that said inlet and said outlet are perpendicular to one another, and wherein a centerline for said outlet is permanently positioned on a centerline for a product carrier line.

21. The product delivery system according to Claim 20, wherein said tubular nozzle outlet and at least one outlet for said product carrier line exit in a common direction.

22. The product delivery system according to Claim 1, further comprising a liquid spray boom assembly having at least one spray boom for delivering said at least one product from said closed transfer product storage means to said predetermined geographical location.

23. The product delivery system according to Claim 22, wherein said spray boom assembly is precharged, such that air trapped within said spray boom assembly remains at a nominal operating pressure within said spray boom assembly, said trapped air within said spray boom asembly eliminating response time lag during activation and deactivation of said boom assembly.

24. A product delivery system, comprising:

a self-propelled vehicle;

a product storage means coupled to said vehicle, for storing and transporting at least one predetermined product to a predetermined geographical area;

a product transfer means coupled to said at least one product storage means, for retrieving said at least one predetermined product from said product storage means; and

a precharged spray boom assembly coupled to said retrieving means, said boom assembly having at least one spray boom for delivering said at least one predetermined product to a predetermined geographical area, said precharged assembly trapping air contained within said boom assembly such that said trapped air remains at a nominal operating pressure within said assembly eliminating response time lag during activation and deactivation of said boom assembly.

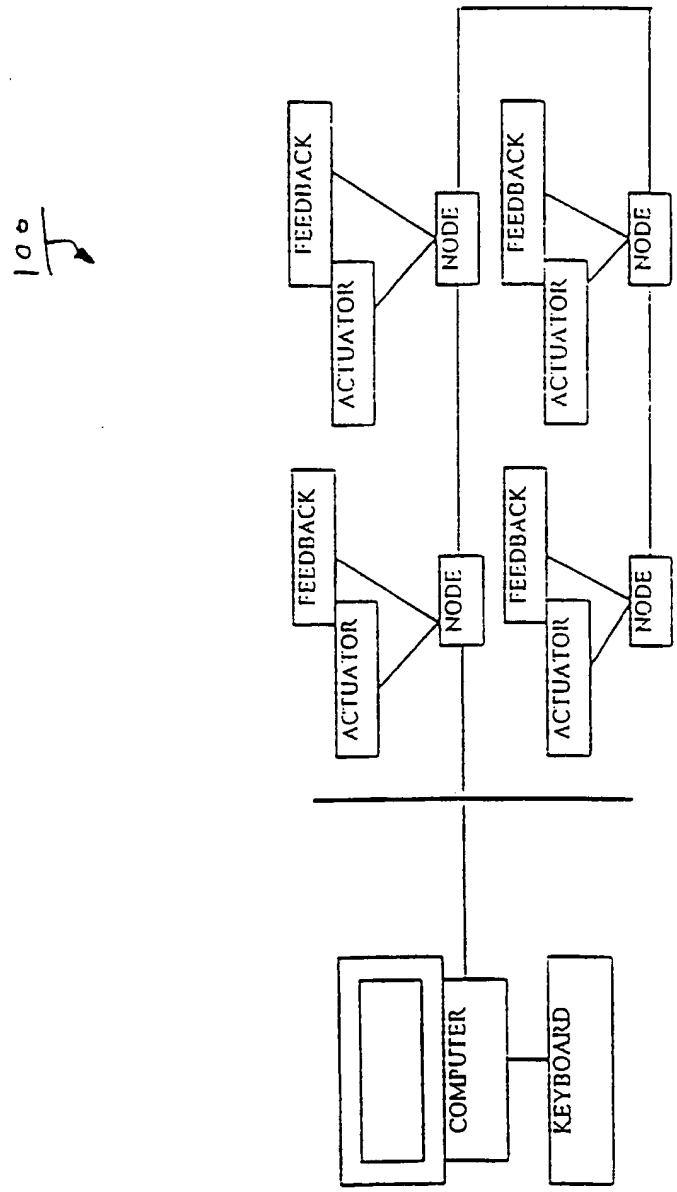
100
FEEDBACK
ACTUATOR
NODE
FEEDBACK
ACTUATOR
NODE
FEEDBACK
ACTUATOR
NODE
FEEDBACK
ACTUATOR
NODE
COMPUTER
KEYBOARD
CAB COMPONENTS
EXTERNAL COMPONENTS

FIGURE 1

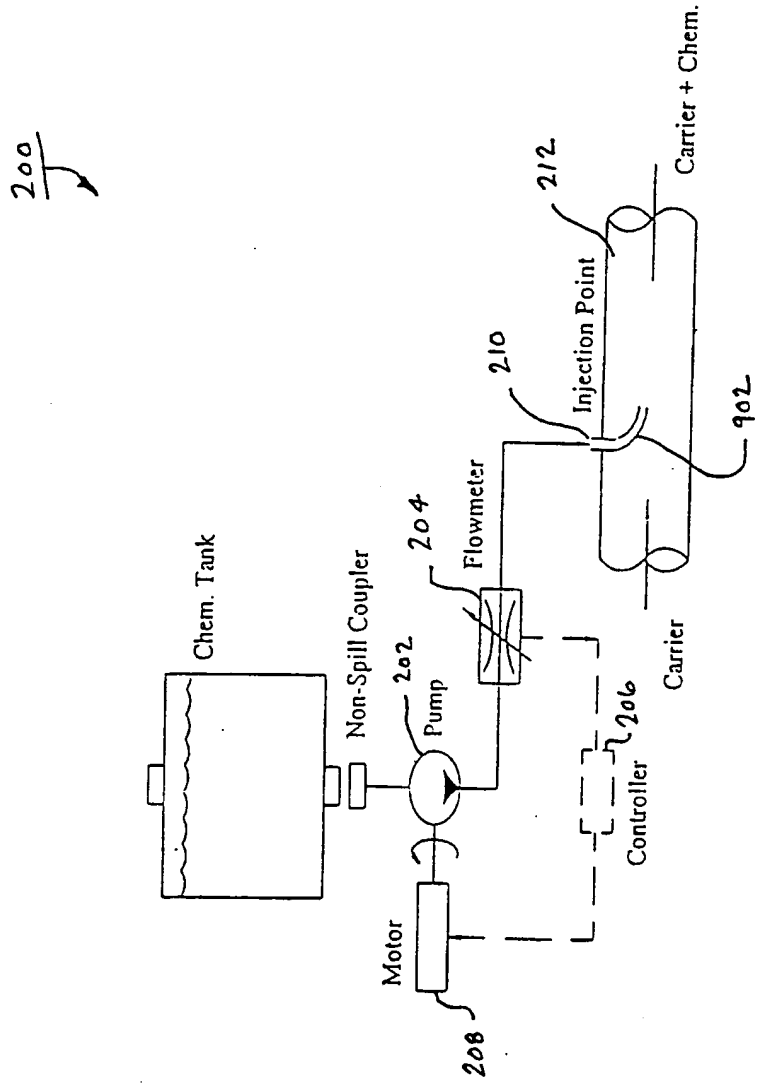
200
Chem. Tank
Non-Spill Coupler
202
Pump
204
Flowmeter
210
Injection Point
212
Carrier + Chem.
902
Carrier
206
Controller
Motor
208

FIGURE 2

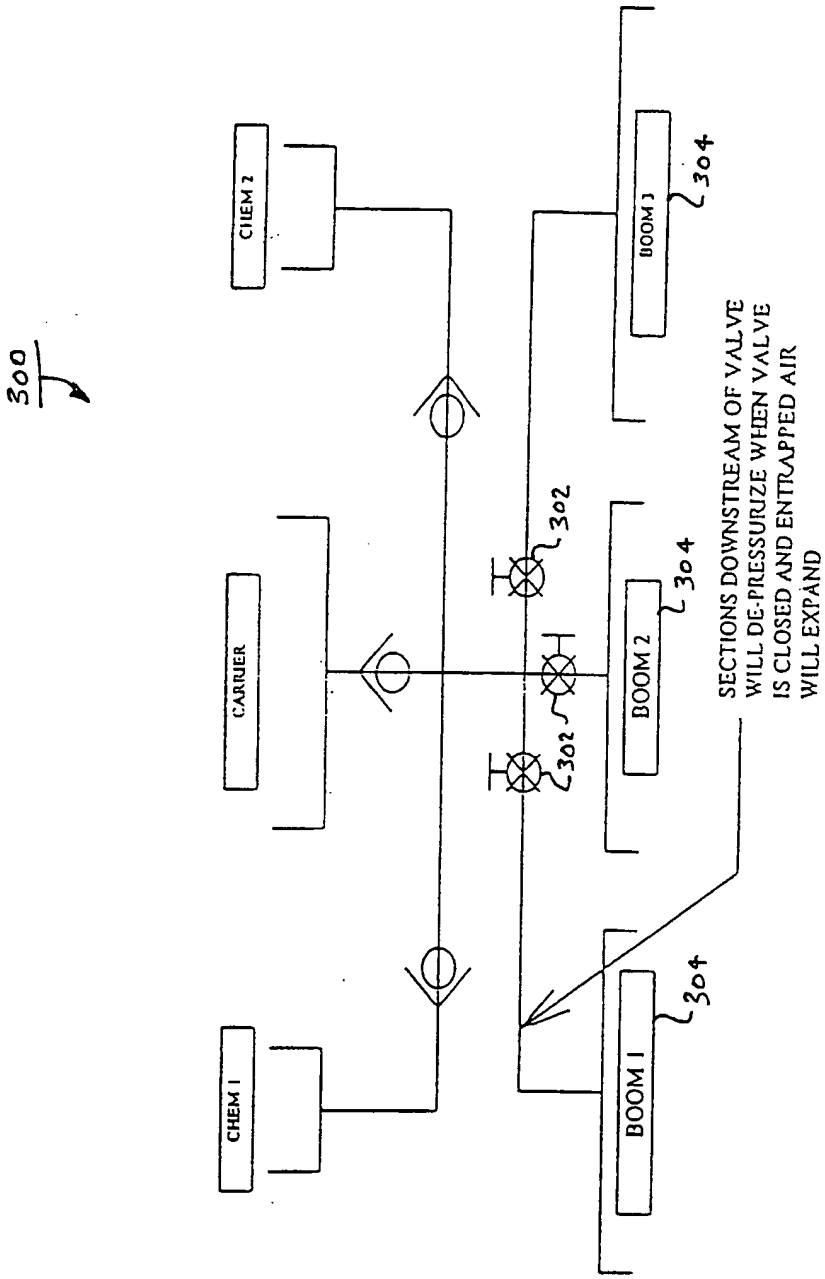
300
CHEM 2
CHEM 1
CARRIER
BOOM 3
BOOM 2
BOOM 1
304
304
304
302
302
SECTIONS DOWNSTREAM OF VALVE
WILL DE-PRESSURIZE WHEN VALVE
IS CLOSED AND ENTRAPPED AIR
WILL EXPAND

FIGURE 3A

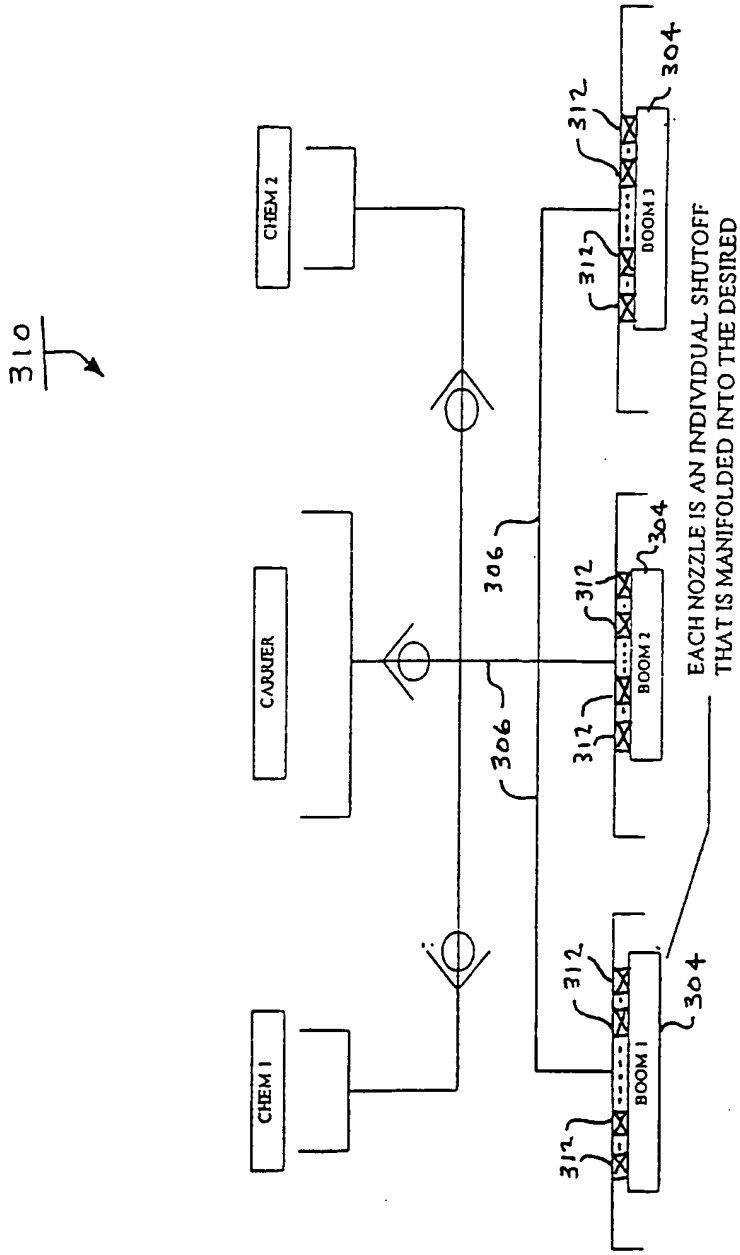
310
CHEM 2
CARRIER
CHEM 1
306
306
312
312
312
312
312
304
304
304
BOOM 3
BOOM 2
BOOM 1
EACH NOZZLE IS AN INDIVIDUAL SHUTOFF
THAT IS MANIFOLDED INTO THE DESIRED
NUMBER OF SECTIONS. THE BOOM LINES ARE
ALWAYS CHARGED WITH PUMP PRESSURE
AND ENTRAPPED AIR IS AT A CONSTANT
PRESSURE

FIGURE 3B

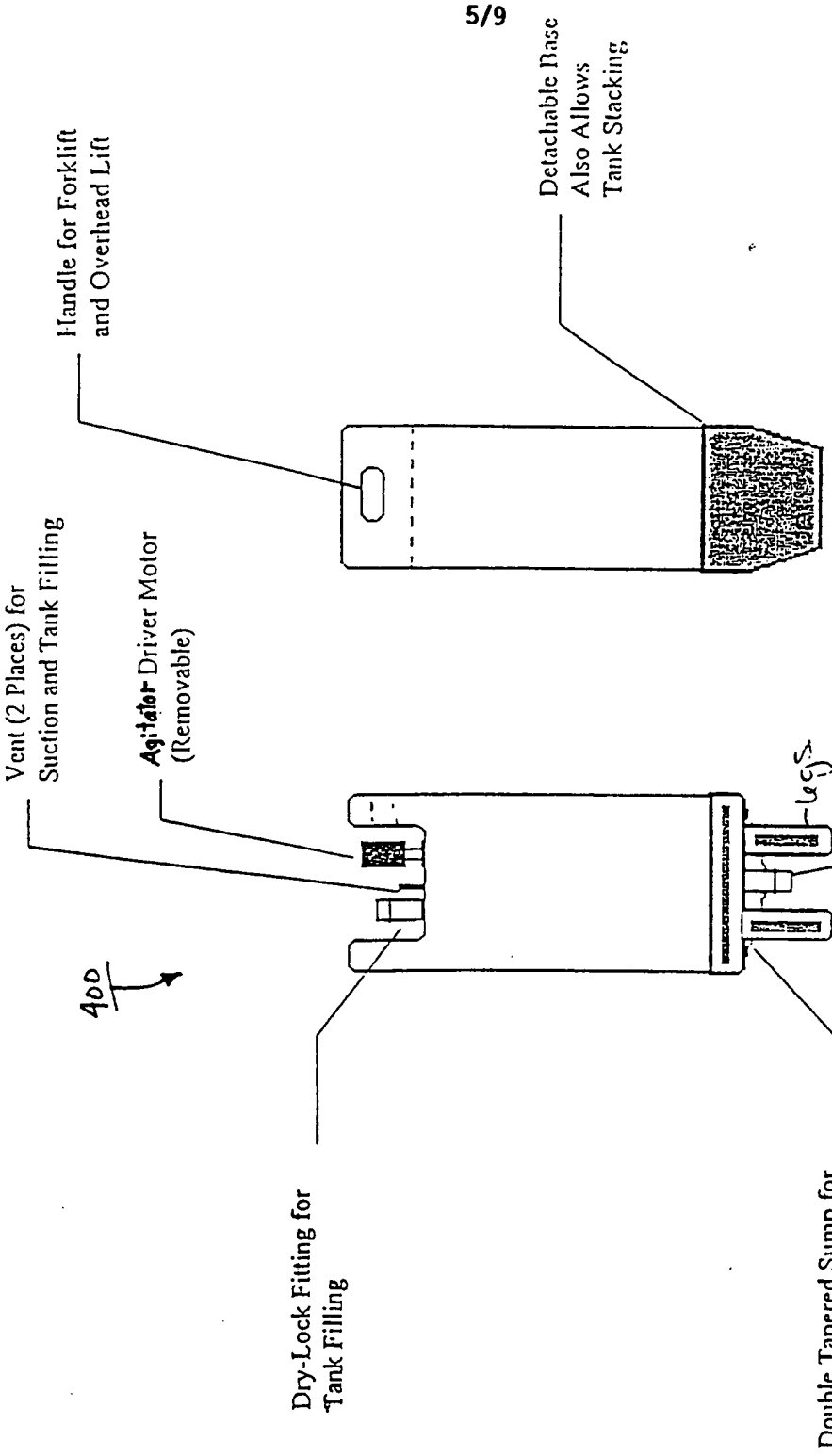

FIGURE 4B

FIGURE 4A

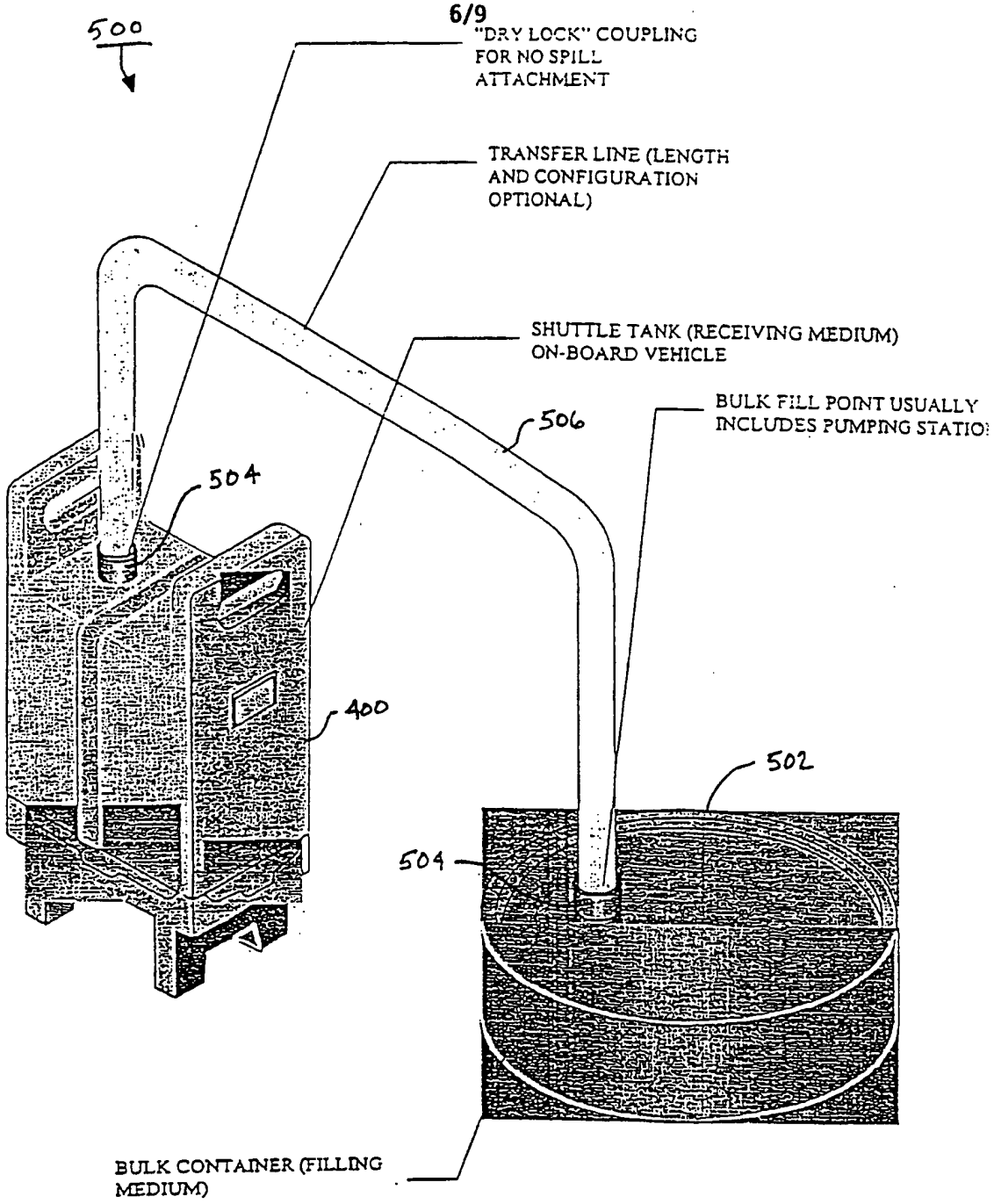
500
"DRY LOCK" COUPLING FOR NO SPILL ATTACHMENT
TRANSFER LINE (LENGTH AND CONFIGURATION OPTIONAL)
SHUTTLE TANK (RECEIVING MEDIUM) ON-BOARD VEHICLE
BULK FILL POINT USUALLY INCLUDES PUMPING STATIO
506
504
400
502
504
BULK CONTAINER (FILLING MEDIUM)

FIGURE 5

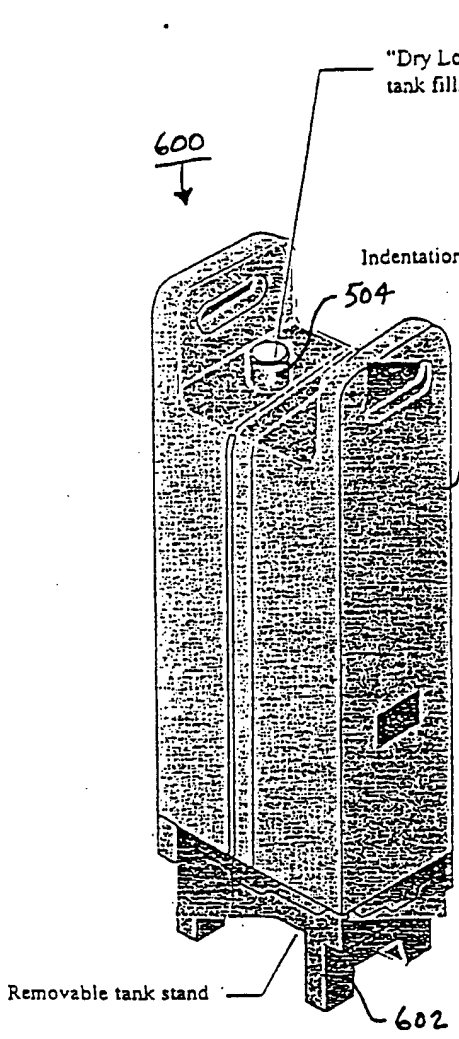

FIGURE 6

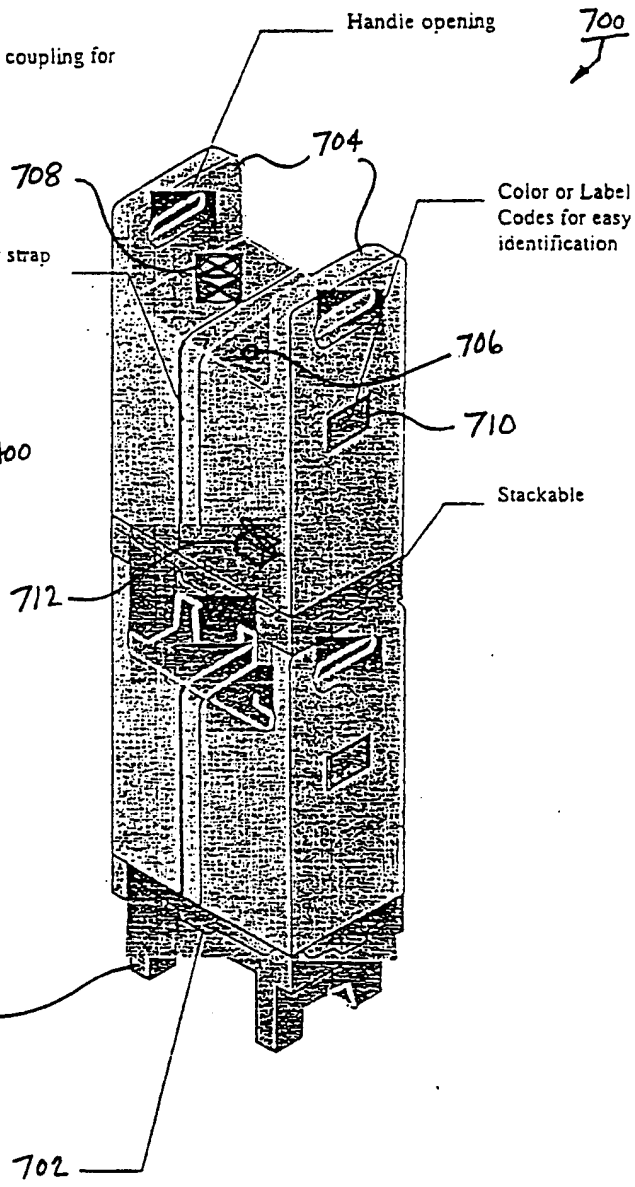

FIGURE 7

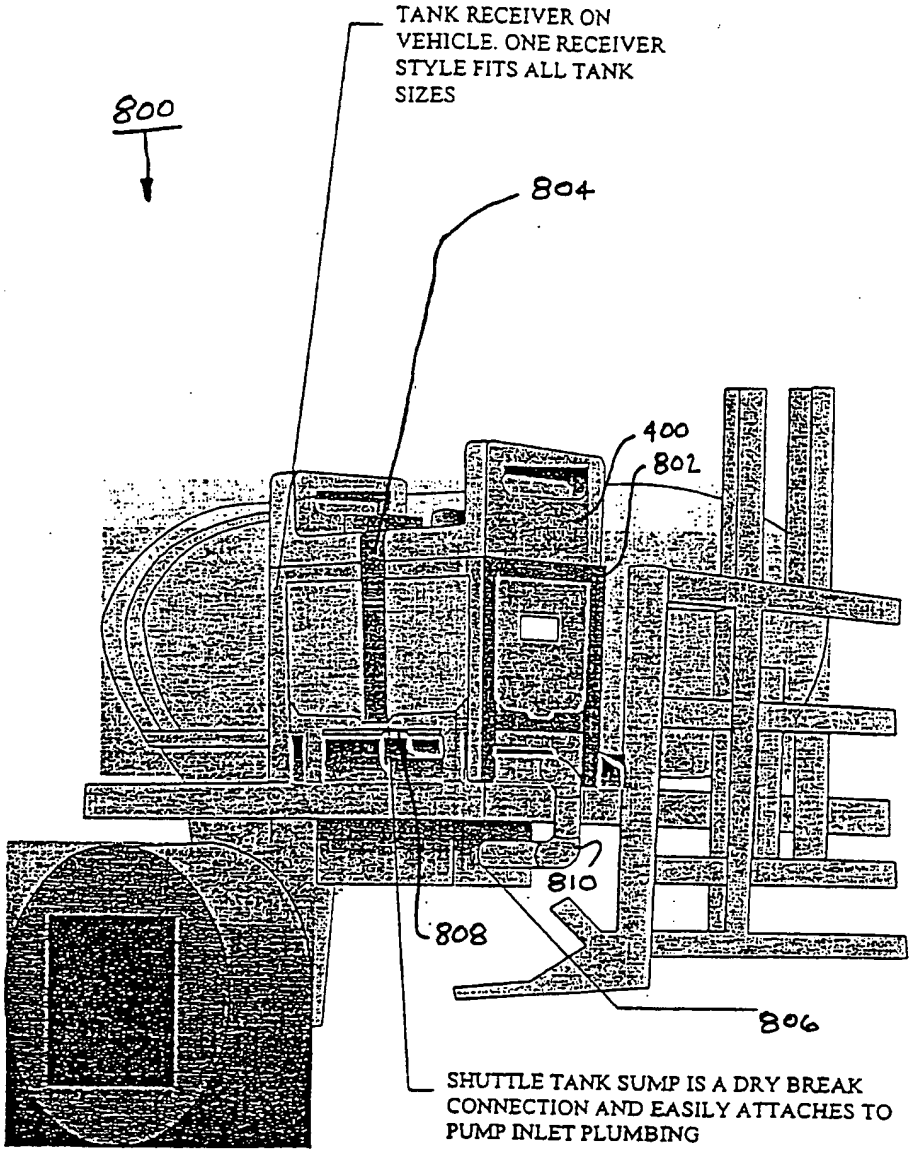
TANK RECEIVER ON VEHICLE. ONE RECEIVER STYLE FITS ALL TANK SIZES
800
804
400
802
810
808
806
SHUTTLE TANK SUMP IS A DRY BREAK CONNECTION AND EASILY ATTACHES TO PUMP INLET PLUMBING

FIGURE 8

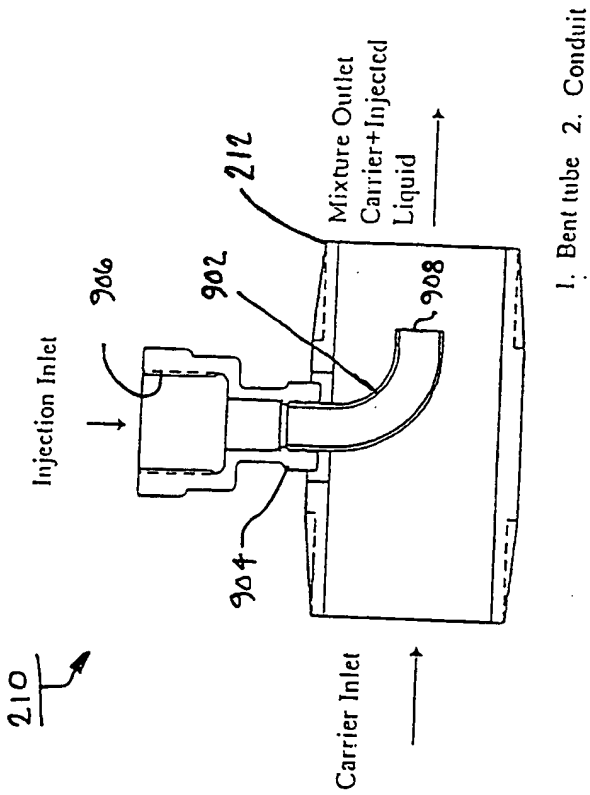
210
Injection Inlet
906
902
212
Mixture Outlet
Carrier+Injected
Liquid
908
904
Carrier Inlet
1. Bent tube 2. Conduit

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/11543

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B05B 7/28; A01G 25/09
US CL :239/163, 310

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 239/10, 61, 63, 146, 148, 159, 163, 172, 310

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE, A, 4,025,943 (Wiemeyer) 20 February 1992 See pump 9 is located at the bottom of the tank.	1, 2, 13, 14, 22
X	US, A, 4,637,547 (Hiniker et al) 20 January 1987 Illustrates a tank, flow meter, controller, pump and booms.	1, 12-14, 16, 17, 23, 24
X	US, A, 5,520,333 (Tofte) 28 May 1996 The description describes employing a GPS with the controller.	1, 12-14, 16-18
Y	US, A, 5,249,684 (Sterett) 05 October 1993 Note the description in col 1 lines 20-25, col 2 lines 30-35 and sump 47.	1-21

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 SEPTEMBER 1996	04 OCT 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Kevin Weldon Telephone No. (703) 308-1117

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/11543

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Kuker Industries, Inc. Catalogue, pg 25, for 1980, see the description of an agitation system in the tank.	7-11, 23, 24
Y	US, A, 2,302,799 (Peterson) 24 November 1942 Note the tube 23 bent at 90 degrees.	19-21
A	US, A, 4,553,702 (Coffee et al) 19 November 1985 See the CPU controllers 206,207.	NONE